C. Butler.

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Kansas State Agricultural College
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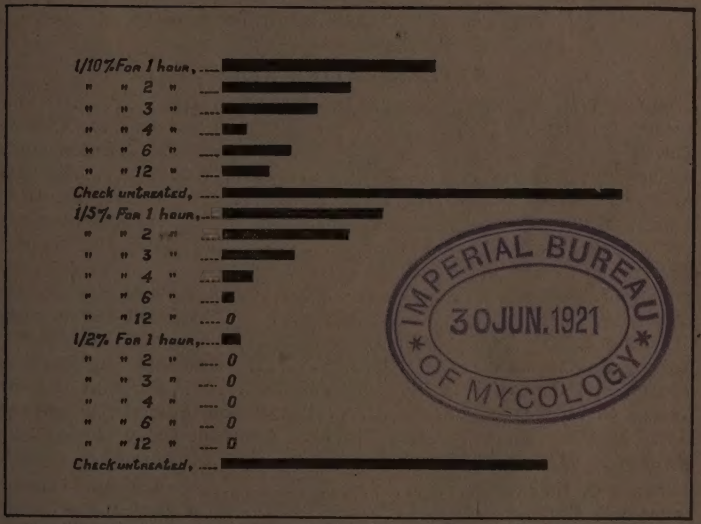
BOTANICAL DEPARTMENT.

PREVENTION OF SORGHUM AND KAFIR-CORN SMUT.



IMPERIAL BUREAU OF MYCOLOGY 30 JUN. 1921

Graphic comparison of the percentage number of the smutted stalks occurring in plots grown from untreated seed of Kafir-corn with those from seed treated with formaldehyde of various strengths and for different periods of time.

BY

H. F. ROBERTS AND GEO. F. FREEMAN.

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BULLETIN No. 149.

THE PREVENTION OF SORGHUM AND KAFIR-CORN SMUT.

BY

H. F. ROBERTS *and* GEO. F. FREEMAN.

SUMMARY.

1. *Grain smut of cultivated sorghum, Kafir-corn, etc., can be absolutely prevented by soaking the seed for two hours in a water solution containing one-half of one per cent. of commercial formaldehyde.*

2. *The cost of the formaldehyde treatment in the above strength amounts to six cents per bushel of seed for the formaldehyde used.*

GRAIN SMUT OF CULTIVATED SORGHUMS.

FORMALDEHYDE TREATMENT.

DESPITE the well-known efficiency of formaldehyde as a convenient fungicide and germicide, nothing conclusive has hitherto been ascertained regarding its value in the treatment of smutted seed of the cultivated sorghums, although the formaldehyde method has been well worked out for the smut of oats. The investigations of Clinton with formaldehyde for grain smut of the sorghums (Ill. Exp. Sta. Bull. 59, March, 1900) constitute the only experiments directed to this problem undertaken hitherto. The results therein reported were wholly inconclusive and indefinite, but nevertheless no subsequent experiments appear to have been instituted in any of the stations, and the matter has remained up to the present exactly in the unfinished state left by Illinois Station Bulletin 59.

In the summer of 1906 a series of experiments instituted by the Botanical department of the Kansas Experiment Station gave final definite solution to the problem with affirmative results.

The cultivated sorghums, saccharine and non-saccharine, including sorghum, Kafir-corn, Jerusalem corn, milo maize, Guinea corn, dhourra, broom-corn, and other varieties, are subject to two principal smut diseases, somewhat closely related in character to the smut disease of corn. The head smut of sorghums reduces the entire head to an amorphous mass, and destroys all semblance of grain. Fortunately this disease, caused by the fungus *Cintractia reliana* (Kühn), is comparatively infrequent. The grain smut, however, caused by *Cintractia sorghi-vulgaris* (Tul.) Clinton, *Ustilago sorghi* (Link), is very common and widespread in this state, and an effective method for its prevention, involving less cumbersome processes than those of the Jensen hot-water treatment, has long been needed.

It will not be necessary in this bulletin to give any extensive account of the life history of the well-known fungus of sorghum smut. For details, reference may be made to the investigations by Clinton in 1897.* Suffice to say here that the black powder called "smut" consists of minute microscopic bodies known as "spores," which, germinating in or upon the soil with the planted seed, send forth slender, delicate germ tubes (called individually "hyphæ," or if much branched, a "mycelium"), which penetrate the growing plantlet, chiefly through the youngest portion of the seedling stem. Entering here, the mycelium grows upward with the plant, remaining invisible from the exterior, and causing no evident alteration in the appearance of the host. With the upward growth of the stalk, terminating in the panicle or head, the fungus grows concurrently until, if it enters the latter during blossoming time or earlier, it causes the abortion of the flowers and brings about monstrosities in the development of the floral organs. Finally, having terminated its vegetative growth with the end of the growing season of the sorghum plant, the fungus produces in the tissue of the seed a dense mass of olive-black spores. The general appearance of the head is not necessarily markedly different from that of the heads unattacked. A close examination of the individual affected grains, however, reveals the existence of a hollow shell of epidermis around the seed, within which is a dense mass of spores, together with small fragments of seed tissue undestroyed. The fungus then ends its life with the close of the growing period of the sor-

* Ill. Exp. Sta. Bull. 47; pp. 380-388 (March, 1897).

ghum host-plant; but its reproductive bodies, the millions of microscopic "spores," surviving the winter in immense numbers, and germinating in the field into which the smutted grain has been drilled, furnish the means for new infections year by year. It should be understood that it is only in the seedling stage that the fungus mycelium enters the sorghum plant, so that means which will kill the spores will effectually prevent infection.

In the experiments made by the Botanical department of this Station during the past season a bushel of very badly smutted seed of black-hulled white Kafir-corn was obtained through the courtesy of one of the senior short-course class of 1906. The seed had been threshed from the head, but the fungus was readily recognizable from the spores as *Cintractia sorghi-vulgaris,* the grain smut. A considerable number of preliminary experiments were made with hanging drop cultures in Van Tieghem cells in the laboratory during the winter, using a carefully graded series of strengths of commercial formaldehyde in tap water, spore germination occurring scarcely at all in distilled water. As the result of these preliminary tests it was determined to use in the field experiments solutions of three strengths, one-tenth, one-fifth and one-half of one per cent., soaking different lots of seed in each solution for periods of from one to twelve hours in the case of the two weaker solutions, and from one to six hours in the case of the one-half of one per cent. solution. The treated Kafir-corn, with two check plots untreated, was planted May 7, 1906. It was very dry at the time of planting, and the stand was at first irregular in all of the plots, owing to a lack of moisture in the soil. A late rain, however, brought up the rest of the seed.

That the irregularity of the stand at first was not due in the least to the treatment given the seed is evidenced by the fact that while one of the check plots, untreated, showed on June 7 a stand of ninety per cent., the plot in the case of which the seed had been soaked for twelve hours in the one-half per cent. solution—the strongest solution and the longest period—gave also a stand of ninety per cent.

The importance in experiments of this nature, of the use of a considerable series of carefully graduated strengths of one fungicide, in preference to a series of many various fungicides of one strength in each case, is sufficiently demonstrated.

The results of the experiment are shown in the following table:

Plot.	Strength of solution.	Hours soaking of seed.	Total stalks in plot.	Number smutted.	Per cent. smutted.
1	1/10 per cent.	1	244	44	18
2	"	2	545	61	11
3	"	3	708	61	8.6
4	"	4	730	15	2
5	"	6	799	45	5.6
6	"	12	601	25	4.2
7	Check untreated		545	182	33.4
8	1/5 per cent.	1	561	76	13.4
9	"	2	367	41	11.2
10	"	3	547	46	8.4
11	"	4	485	11	2.2
12	"	6	584	7	1.2
13	"	12	506	0	0
14	1/2 per cent.	1	640	10	1.8
15	"	2	616	0	0
16	"	3	666	0	0
17	"	4	729	0	0
18	"	6	703	0	0
19	"	12	706	0	0
20	Check untreated		654	181	27.8

From the table of results it appears that the spores of the sorghum smut fungus can be absolutely killed by soaking the seed in either one of the following two strengths: One-fifth per cent. for twelve hours, or one-half per cent. for two hours; while one-tenth per cent. for three hours yields better results by one per cent. than those obtained by Clinton with sorghum seed, using approximately a three-tenths per cent. solution, but apparently applying the fungicide by sprinkling rather than by soaking the seed.

In view of the fact that soaking the seed of Kafir-corn for as much as twelve hours in the one-half per cent. solution does not in the least affect the stand as compared with the check plots, it is evident that the one-half per cent. solution can safely be used for two hours, for treating the grain smut of sorghums, in the case of the threshed grain of all the cultivated varieties in which the seeds are well exposed and not enclosed by glumes or chaff.

In view of the lesser time required for soaking, it is evidently better to use the stronger solution for two hours than the weaker one for twelve hours, other things being equal.

Formaldehyde is a gas soluble in water to a saturation

strength of forty per cent., and in calculating percentages here this commercial solution is taken as 100. The commercial formaldehyde, also sold under the trade name of "formalin" (at a higher price), is therefore simply a forty per cent. aqueous solution of formaldehyde gas. The solution is clear and transparent, having an intense biting odor, due to the fumes of formaldehyde gas escaping from solution. The gas is extremely irritating to the mucous membrane of the eyes, nose, and throat, and is corroding to the skin to a certain extent. Care must therefore be exercised in handling, to avoid accidents, and the solution should always be kept out of the reach of children and irresponsible persons. At the same time it is not in the least dangerous to handle; and with proper care, not the slightest inconvenience need be experienced. In general it may be said that the most satisfactory procedure in the treatment of sorghum or Kafir-corn for grain smut is to hang the smutted seed, enclosed in a loose burlap bag, within a barrel, into which the formaldehyde solution has previously been poured. Cover the top of the barrel in order to retain as much as possible the escaping fumes of formaldehyde gas. After treatment, the seed should be spread out upon a clean floor to dry, turning the seed over every few hours until it has become thoroughly dried out. It should be remembered that if there is any doubt as to the character of the floor upon which the seed is to be spread, the floor itself should first be disinfected. For this purpose a strong lye solution will be found sufficient.

The smutted seed may be treated in the manner described, immediately after harvesting, and may then be stored until the following spring. Too much emphasis cannot be laid upon the necessity for *thorough drying* of the seed after treatment.

With respect to the cost of disinfecting seed by the formaldehyde method, it may be stated that commercial forty per cent. formaldehyde retails at about thirty cents per pound (pint), to which should be added the express or freight, if the reagent is ordered from a wholesale house. In general, it will be better for several growers to unite on a common purchase from some well-known drug or chemical house. A list of such concerns can be obtained by writing to the Experiment Station.

Using the one-half of one per cent. solution, the cost of treatment would be at the rate of about six cents per bushel of seed for the formaldehyde used.